Gas Transmission Northwest
Compressor Station No. 12
Unit 12B Cost Effectiveness Calculation Update Based on Vendor Cost Quote

Based on recent discussions with DEQ, support documentation regarding SCR performance, and a cost quote for Station 12, Unit 12B, an updated cost effectiveness calculation spreadsheet follows. Notes regarding the analysis and changes from the 2020 submittal follow:

- Vendor cost quote is attached. In the two-week period between the February and March web meetings with DEQ, the vendor was able to provide a quote for one unit: 12B
- Changes to the previous submittal are highlighted in yellow in the Excel sheet / table below.
- Capital costs (including related costs in adjacent rows) were marginally increased based on the vendor quote. The vendor provided a cost range, and the upper end applies because "tempering air" system is needed to ensure the exhaust temperature at the catalyst inlet is less than the design maximum. For simple cycle turbines, higher exhaust temperature requires this system.
- Aqueous ammonia reagent cost updated based on vendor quote of hourly feed rate (i.e., 7.7 gallons per hour of 19% aqueous ammonia), assumed operating hours, and reagent cost of $1.05 per gallon.
  - Aqueous ammonia cost per gallon from cost quote (attached) for delivery to site with 8,000 gallon tank. Fuel surcharge varies; costs provided ($1.012 per gallon) rounded up to $1.05 per gallon to include an estimate of fuel surcharge.
- Annual maintenance materials costs marginally increased based on vendor quote. (Note that additional review is continuing regarding potentially larger annual maintenance (labor) costs based on users' experience.)
- In response to DEQ questions, an IES memo documents examples of SCR NOx reduction performance for SCR application to natural gas transmission compressor drivers. That memo supports the assumption in the GTN 2020 four factor analysis that assumed 75% reduction (or even 70% reduction) for units 12A, 12B, 13C, and 13D.
- **Updated cost-effectiveness value is $12,676 per ton**, assuming PSEL based on 8,760 operating hours. Additional examples assuming other operating hours or utilization:
  - Same as above with DEQ assumption of 90% control: $10,563 per ton
  - 80% control: $11,883 per ton
  - 75% control and 75% utilization: $16,590 per ton
  - 75% control and future forecast of high-end utilization (42.5%): $28,562 per ton

Table 2. Rolls Royce Avon Turbine (Unit 12B) SCR NOx Control Cost Effectiveness (100% utilization case).

NOx Control Cost Effectiveness Estimate

	Engine Manufacturer	Cooper-Rolls				
	Model No.	Avon				
	Unit ID	12B				
	Fuel Used	Natural Gas				**Color Legend**
	Emissions Control	SCR				User Data / Information Input Cell
	Combustion Control Purpose	NOx				"Cumulative" Cost Cell for Primary Categories
	Target Reduction	75%				Cost Effectiveness ($ / ton)
1	**Engine Design Conditions**					**Comments**
	Power Output	14300	(hp)			Rated HP
	Engine Exhaust Temperature		(F)			*optional input*
	Engine Exhaust Rate		(lb/hr)			*optional input*
	Gas Volume		(dscfm)			*optional input*
2	**Full Load Engine Exhaust Composition:**					**Comments**
	Oxygen (O_2)		(vol. %)			*optional input*
	Carbon Dioxide (CO_2)		(vol. %)			*optional input*
	Water (H_2O)		(vol. %)			*optional input*
	Oxides of Nitrogen (NOx)		(ppmvd)			*optional input*
	Nitrogen (N_2)		(vol. %)			*optional input*
	NOx	23.1	lb/hr	0.170	(lb/MMBtu)	NOx emissions from test Data: 173.9 lb/MMSCF ~0.170 lb/MMBtu
3	**Engine Parameters**					**Comments**
	Total Operating Hours per Season	8760	(hrs)	100.0%	utilization	
4	**Final Exhaust Gas Composition**					**Comments**
	Oxides of Nitrogen (NOx)	5.8	lb/hr	0.043	(lb/MMBtu)	Assume 75% reduction
5	**Economic Parameters**					**Comments**
	Source of Cost Data	see Analysis				Analysis primarily relying on EPA Cost Manual
	Direct Costs		**Cost Formula**			**Comments**
	Combustion Control Equipment and Auxiliary Equipment	$3,000,000	(A)			Updated per AeriNox proposal for SCR system hardware costs ($3,300,000); tempering air needed to ensure exhaust temperature <900F
	Instrumentation	$300,000	(0.1*A)			
	Sales Taxes	$0	(0.03*(A+instrumentation))			No Oregon sales tax
	Freight	$185,000	(0.05*A)			Updated per freight estimate in AeriNox proposal
	Purchased Equipment Cost (PEC)	**$3,485,000**	PEC			
6	**Direct Installation Costs**		**Cost Formula**			**Comments**
	Foundations and Supports	$278,800	(0.08*PEC)			Calculated Cost using EPA Control Cost Manual
	Handling and Erection	$487,900	(0.14*PEC)			Calculated Cost using EPA Control Cost Manual
	Electrical	$139,400	(0.04*PEC)			Calculated Cost using EPA Control Cost Manual
	Piping	$69,700	(0.02*PEC)			Calculated Cost using EPA Control Cost Manual
	Insulation for ductwork	$34,850	(0.01*PEC)			Calculated Cost using EPA Control Cost Manual
	Painting	$34,850	(0.01*PEC)			Calculated Cost using EPA Control Cost Manual
	Site Preparation	$0	SP			Cost included with next row
	Buildings	$1,035,000	Bldg			Quote for major reconstruction to accommodate retrofit
	Total Installation Cost (TIC)	**$2,080,500**				
	Total Direct Costs (PEC+TIC)	**$5,565,500**				

Table 2 (continued).

7	**Indirect Costs**		**Cost Formula**			**Comments**
	Engineering	$348,500	(0.10*PEC)			Calculated Cost using EPA Control Cost Manual
	Construction and field expenses	$174,250	(0.05*PEC)			Calculated Cost using EPA Control Cost Manual
	Contractor fees	$348,500	(0.10*PEC)			Calculated Cost using EPA Control Cost Manual
	Start-up	$69,700	(0.02*PEC)			Calculated Cost using EPA Control Cost Manual
	Performance test	$34,850	(0.01*PEC)			Calculated Cost using EPA Control Cost Manual
	Contingencies	$104,550	(0.03*PEC)			Calculated Cost using EPA Control Cost Manual
	Total Indirect Costs (IC)	**$1,080,350**	(0.31*PEC)			
8	**Capital Cost Summary**					**Comments**
	Total Direct Capital Costs (DC)	$5,565,500				
	Total Indirect Capital Costs (IC)	$1,080,350				
	Total Capital Investment (TCI)	**$6,645,850**				
9	**Direct Annual Costs**		**Cost Formula**			**Comments**
	Operator Labor	$26,000	nominal cost			5 hours per week (1 hr x 5 days); job category labor rate
	Supervisor Labor	$3,900				15% of operator
	Operating Materials - ammonia	$70,825				materials estimates:7.7 gals aqueous NH3/hr at cost of $1.05 / gallon
	Maintenance - Labor	$26,000	nominal cost			5 hours per week (1 hr x 5 days); job category labor rate
	Maintenance - Materials	$8,000	nominal cost			Updated per AeriNOx quote for annual service parts
	Catalyst maintenance / replacement	$150,000				Engineering Estimate (5% of Cap Cost)
	Testing and QA/QC	$20,000				Engineering estimate - Annual test; reagent controller QA
	Electricity	$2,500				Estimate based on analysis in PA DEP TSD
	Total Direct Annual Costs	**$307,225**				
10	**Indirect Annual Costs**		**Cost Formula**	**Capital Recovery Factor**		**Comments**
	Overhead	$38,340	(0.6*(OL+SL+ML+MM))			
	Administrative Charges	$132,917	(0.02*TCI)			Engine ACT Document
	Property Taxes	$66,459	(0.01*TCI)			Engine ACT Document
	Insurance	$66,459	(0.01*TCI)		**CRF**	
	Capital Recovery	$350,236	CRF[TCI]		0.0527	Factor for costs annualized over 30 years at 3.25% interest.
	Total Indirect Annual Costs	**$654,410**				CRF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = 0.1)
11	**Summary**					**Comments**
	Total Direct Annual Operating Costs	$307,225				
	Total Indirect Annual Operating Costs	$654,410				
	Total Annual Costs	$961,635		$67	$ per hp	
	Incremental Annual Costs Over Baseline	$961,635				
12	**Annual Emissions Reduction Over Baseline**					**Comments**
	Oxides of Nitrogen (NOx)	75.87	(Tons)			
	Cost Effectiveness ($/Ton)					**Comments**
	Oxides of Nitrogen (NOx) - $ per ton	$12,676				PSEL basis: **significantly over-estimates utilization**